MULTIMEDIA UNIVERSITY

STUDENT ID NO

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |

# MULTIMEDIA UNIVERSITY

# FINAL EXAMINATION

**TRIMESTER 1, 2017 / 2018**

## PPH0135 - ELECTRICITY AND MAGNETISM

(Foundation in Engineering)

14 OCTOBER 2017
9.00 a.m. – 11.00 a.m.
(2 Hours)

---

**INSTRUCTIONS TO STUDENT**

1. This question paper consists of **SIX** printed pages, excluding the cover page and appendices, with **FIVE** questions.
2. Answer all questions. The distribution of the marks for each question is given.
3. Write all your answers in the answer booklet provided.
4. All necessary workings must be shown.

## QUESTION 1 (10 marks)

a) Two equal-magnitude point charges, $q_1 = +3.0\ \mu C$ and $q_2 = -3.0\ \mu C$ are located at opposite corners of a square which is 10.0 cm on a side, as shown in **Figure Q1.1**.

i. Define electric field at a point.

(1 mark)

ii. What are the directions of electric field for each of the charges at the centre of the square?

(1 mark)

iii. Find the magnitude and direction of resultant electric field at the centre of the square due to the two charges.

(3 marks)

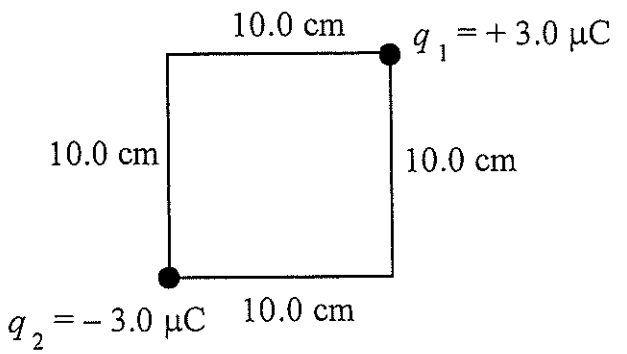


**Figure Q1.1**

b) **Figure Q1.2** shows a circuit consists of two uncharged capacitors and a 6-V battery. Initially switch $S_1$ is closed, and after one of the capacitors is fully charged in this arrangement, the 6-V battery is removed from the circuit and then $S_2$ is closed. Calculate the final charge on $C_1$.

(5 marks)

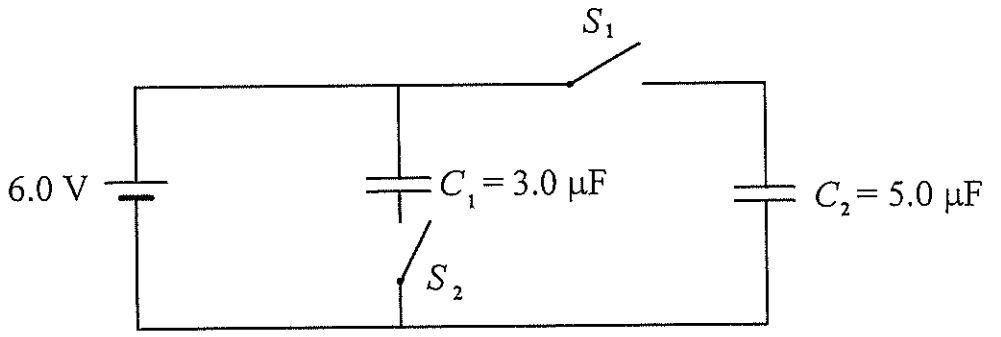


**Figure Q1.2**

**Continued...**

## QUESTION 2 (10 marks)

a) **Figure Q2.1** shows a particle moves along a circle in a region of uniform magnetic field directed into the page with a magnitude of $B = 3.50 \times 10^{-3}$ T. The particle is either a proton or an electron. It experiences a magnetic force with a magnitude of $4.00 \times 10^{-15}$ N.

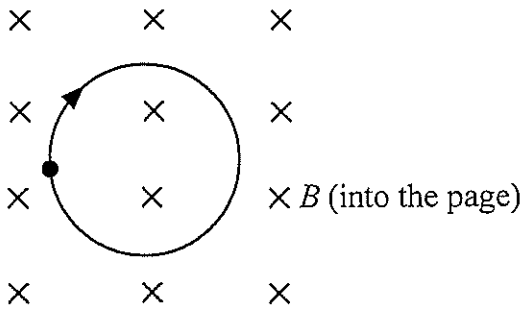


**Figure Q2.1**

i. Is the particle a proton or an electron?

(1 mark)

ii. What is the speed of the particle?

(1 mark)

iii. Calculate the radius of the circle.

(1 mark)

b) **Figure Q2.2** shows a cross section of two straight and long current-carrying wires, $I_1$ and $I_2$, perpendicular to the page. Determine the magnitude and the direction of the resultant magnetic field at point $P$ due to both wires.

(4 marks)

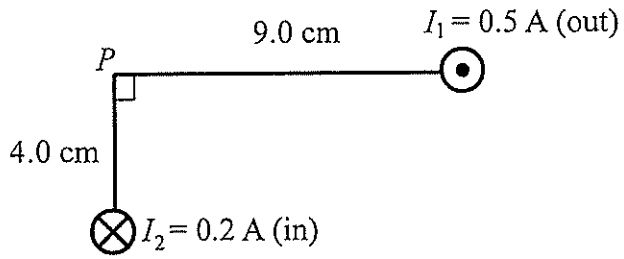


**Figure Q2.2**

c) A circular loop of wire with diameter of 3.0 m and resistance of 2.0 Ω is placed in a magnetic field ($B$) pointing out of the page as shown in **Figure Q2.3**. If the magnetic field is decreasing at a rate of 4.0 (mT)/s, determine the magnitude and the direction of the induced current in the loop.

(3 marks)

**Continued...**

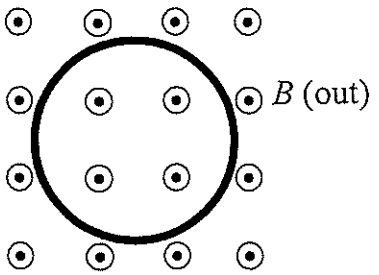


**Figure Q2.3**

## QUESTION 3 (10 marks)

a) A piece of carbon film with dimensions of 6.0 mm × 2.0 mm × 10.0 μm is connected to a 1.5-V battery as shown in **Figure Q3.1**. The resistivity of the carbon is $3.5 \times 10^{-5}$ Ωm and the battery is connected to the film at side $PQ$ and side $SR$.

i. Write Ohm's law equation. (1 mark)

ii. Determine the current flowing through the Ammeter $A$. (3 marks)

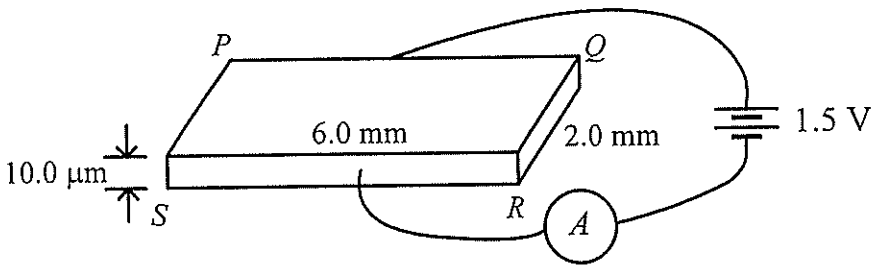


**Figure Q3.1**

b) Three resistors are connected to a 4.0 V battery as shown in **Figure Q3.2**. If the voltage across $R_1$ is 3.0 V, determine

i. The total current in the circuit ($I_T$). (1 mark)

ii. The value of resistance $R_3$. (2 marks)

**Continued...**

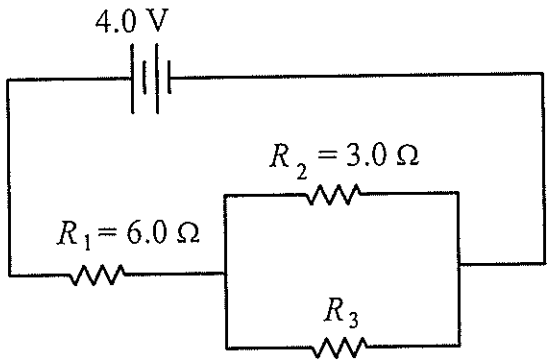


**Figure Q3.2**

c) **Figure Q3.3** shows a circuit consists of two batteries and three resistors.

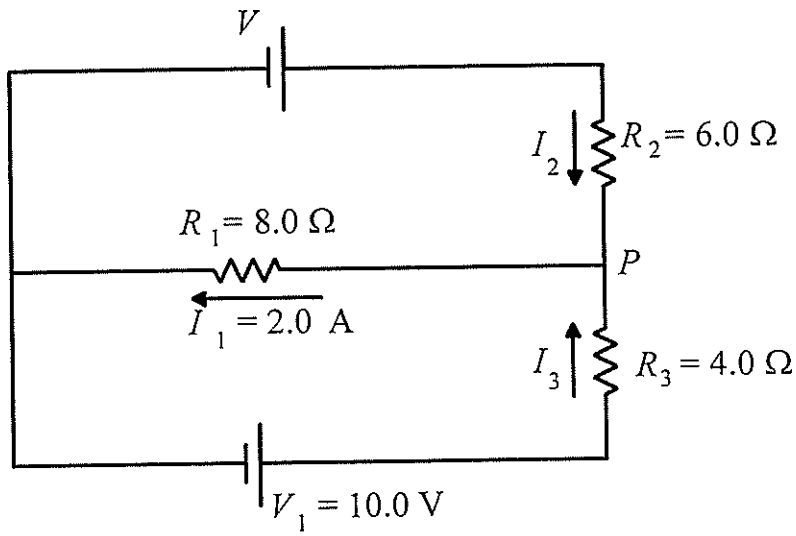


**Figure Q3.3**

i. Write the equation of Kirchhoff's voltage law for the loop that consists of $V_1$, $R_1$ and $R_3$ in terms of $V$, $I$ and $R$.

(0.5 marks)

ii. Write the equation of Kirchhoff's current law at point $P$.

(0.5 marks)

iii. Use your answers in parts (i) and (ii) to find the value of voltage $V$.

(2 marks)

**Continued...**

## QUESTION 4 (10 marks)

a) An alternating emf source with a certain emf amplitude is connected, in turn, to a resistor, a capacitor and then an inductor. Once connected to one of the devices, the driven frequency $f_d$ is varied and the amplitude $I$ of the resulting current through the device is measured and plotted as shown in **Figure Q4**. Match the three plots ($p$ $q$, $r$) to the corresponding devices.

(3 marks)

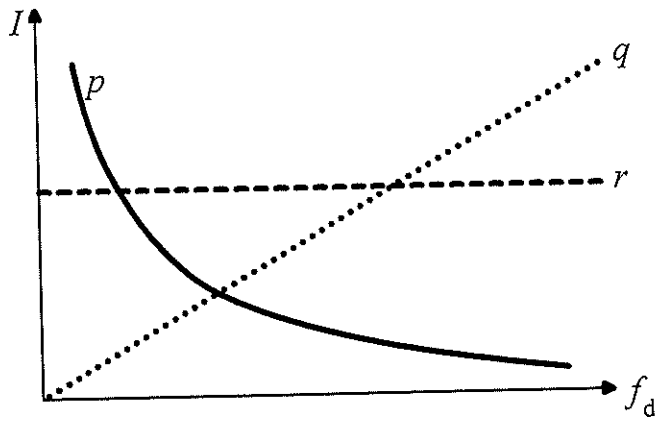


**Figure Q4**

b) In a series *RLC* circuit operating at 60 Hz, the maximum voltage across the inductor ($V_L$) is two times the maximum voltage across the resistor ($V_R$) and two times the maximum voltage across the capacitor ($V_C$).

i. Sketch the phasor diagram of the voltages mentioned above.

(2 marks)

ii. Does the current in the circuit lag or lead the generator emf?

(1 mark)

iii. Calculate the phase angle.

(2 marks)

iv. If the maximum generator emf is 30.0 V, what should be the resistance of the circuit to obtain a maximum current of 300 mA?

(2 marks)

**Continued...**

## QUESTION 5 (10 marks)

a) An n-type silicon can be obtained by a doping process where pentavalent impurities such as arsenic (As) are added to a pure silicon. Explain the doping process to obtain the n-type silicon.

(3 marks)

b) Two silicon diodes $D_1$ and $D_2$ are connected in a circuit as shown in **Figure Q5.1**.

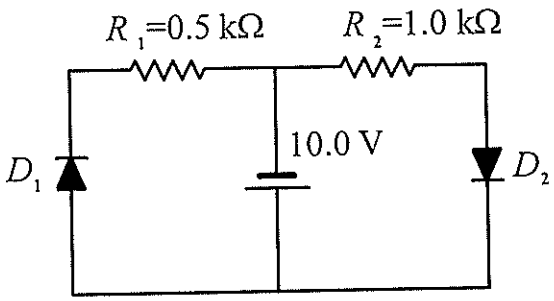


**Figure Q5.1**

i. State the bias conditions for each of the diodes.

(1 mark)

ii. Find the current flowing through each of the resistors.

(2 marks)

c) Find the magnitude of $I_B$, $I_E$ and $I_C$ in **Figure Q5.2** given that $\alpha_{dc} = 0.98$. Assume that the transistor is of silicon type.

(4 marks)

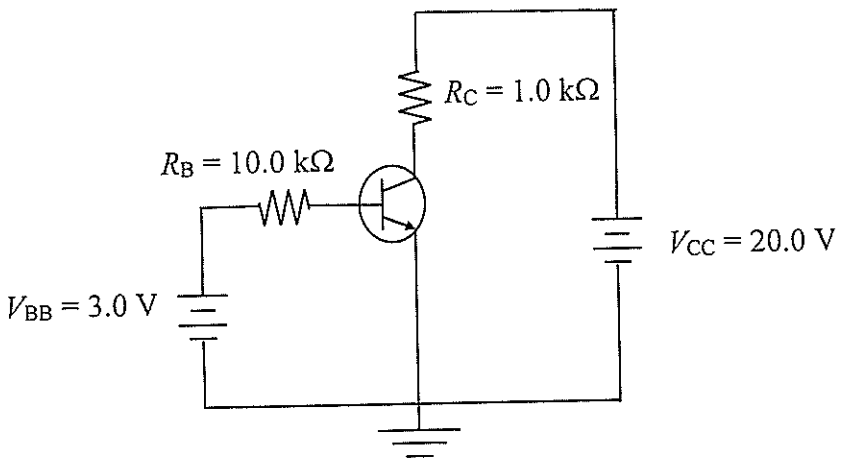


**Figure Q5.2**

**End of page**

## APPENDIX I

**Physical Constants**

| Quantity | Symbol | Value |
|---|---|---|
| Electron mass | $m_e$ | $9.11 \times 10^{-31}$ kg |
| Proton mass, | $m_p$ | $1.67 \times 10^{-27}$ kg |
| Elementary charge | $e$ | $1.602 \times 10^{-19}$ C |
| Gravitational constant | $G$ | $6.67 \times 10^{-11}$ N.m$^2$ /kg$^2$ |
| Gas constant | $R$ | 8.314 J/K.mol |
| Hydrogen ground state | $E_o$ | -13.6 eV |
| Boltzmann's constant | $k_B$ | $1.38 \times 10^{-23}$ J/K |
| Compton wavelength | $\lambda_c$ | $2.426 \times 10^{-12}$ m |
| Planck's constant | $h$ | $6.626 \times 10^{-34}$ J.s |
| Speed of light in vacuum | $c$ | $3.0 \times 10^{8}$ m/s |
| Rydberg constant | $R_H$ | $1.097 \times 10^{7}$ m$^{-1}$ |
| Acceleration due to gravity, | $g$ | 9.81 m /s$^2$ |
| Atomic mass unit (1u) | u | $1.66 \times 10^{-27}$ kg |
| Avogadro's number | $N_A$ | $6.023 \times 10^{23}$ mol$^{-1}$ |
| Threshold of intensity of hearing | $I_o$ | $1.0 \times 10^{-12}$ W /m$^2$ |
| Coulomb constant | $k$ | $8.988 \times 10^{9}$ N m$^2$ /C$^2$ |
| Permittivity of free space | $\varepsilon_o/\kappa_o$ | $8.85 \times 10^{-12}$ C$^2$/N.m$^2$ |
| Permeability of free space | $\mu_o$ | $4\pi \times 10^{-7}$ H/m |

Energy equivalent of atomic mass unit:

One atomic mass unit (1.0 u) is equivalent to 931.5 MeV

## APPENDIX II

### List of formulas

$$A_v = \frac{V_c}{V_b}$$

$$\alpha_{dc} = \frac{\beta_{dc}}{\beta_{dc}+1}$$

$$\beta_{dc} = \frac{\alpha_{dc}}{1-\alpha_{dc}}$$

$$B = \frac{\mu_0 I}{2\pi r}$$

$$B = \mu_0 nI$$

$$\xi = V + Ir$$

$$\xi = blv$$

$$\xi = -N\frac{\Delta\Phi}{\Delta t}$$

$$\xi = -L\frac{dI}{dt}$$

$$\xi = -M\frac{dI}{dt}$$

$$F = BIL\sin\theta$$

$$F = qvB\sin\theta$$

$$\frac{F}{\ell} = \frac{\mu_0 I_1 I_2}{2\pi d}$$

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

$$I_{tot} = \sqrt{I_R^2 + (I_L - I_C)^2}$$

$$I = neA(v_n + v_p)$$

$$I = nev_d A$$

$$I = I_{max}\sin\omega t$$

$$I_{rms} = \frac{I_{max}}{\sqrt{2}}$$

$$I_x = \left(\frac{R_T}{R_x}\right)I_T$$

$$L = \frac{N\Phi_B}{I}$$

$$L = \frac{\mu_o N^2 A}{l}$$

$$M = \frac{N\Phi_B}{I}$$

$$M = \frac{\mu_o N_1 N_2 A}{l}$$

$$P = IV = I^2R = \frac{V^2}{R}$$

$$P_t = I_{rms}V_{rms}\cos\phi$$

$$P_r = V_{rms}I_{rms}\sin\phi$$

$$P_a = I_{rms}^2 Z$$

$$R = \frac{\rho L}{A}$$

$$R = R_0\left[1+\alpha(T-T_0)\right]$$

$$R_T = R_1 + R_2 + R_3 + \ldots$$

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$$

$$r = \frac{mv}{Bq}$$

$$\tau = NBIA\sin\theta$$

$$U = \frac{1}{2}LI^2$$

$$U = \frac{1}{2}B^2 A\frac{l}{\mu_o}$$

$$V_H = Bvd$$

$$V = V_{max}\sin\omega t$$

$$V_{rms} = \frac{V_{max}}{\sqrt{2}}$$

$$V_x = \left(\frac{R_x}{R_T}\right)V_S$$

$$X_C = \frac{1}{2\pi fC}$$

$$X_L = 2\pi f L$$

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

$$\oint B.dl = \mu_o I$$

$$d\mathbf{B} = \frac{\mu_O I}{4\pi}\frac{d\ell\times\hat{\mathbf{r}}}{r^2}$$

$$\Phi_B = BA\cos\theta$$

$$\cos\phi = \frac{R}{Z}$$

$$\tan\phi = \frac{X_L - X_C}{R}$$